This research investigates various methods of fast moving valve operation, namely piezoelectric and electromagnetic methods. Due to certain insufficiencies in existing methods, we designed our own electromagnetic “moving disk” valve capable of both static and pulsing operation, and after testing a prototype of this design, we found it to be capable of 70 μm rise times with even faster times possible with further optimization. This technology is mainly applicable in fusion research, but further applications may present themselves in the future.

### Previous Valve Designs

- **Piezoelectricity**: property of a material that expands/contracts when a voltage is placed across it.
- **Used in fast puff valves with piezoelectric disk actuators (Figure 1a)**:
  - Piezoelectric ceramic laminated to the bottom of a stainless steel disk attached to a metal plunger.
  - Voltage across the two faces electrically contracts the piezoelectric disk to cup upward.
  - Plunger is lifted slightly upward to open the orifice and allow gas to flow through the valve.
- **Advantages**: Quick pulsing operation as well as longer static operation.
- **Disadvantages**: Voltage limit exists.
  - Larger actuators = larger distances at slower frequencies.
  - Smaller actuators = higher frequencies over small distances.
  - Increasing voltage past a certain threshold (usually 1000 V) depolarizes piezoceramics.
- **Collaborated with UW research group looking into a piezoelectric valve design (Figure 1b)**.
  - PUT IN FINAL EXPERIMENTAL RESULTS!!!
  - Rise time was slower than we had hoped, necessary to pursue different methods.

### Proposed Valve Design

- **Developed an electromagnetic valve capable of static operation (Figure 2)**

#### Experimental Setup

- **Piezoelectric displacement sensor within the gas inlet of the valve to measure distance**
  - Instrument emits light from the end of its fiber bundles and reflects back off moving disk.
  - Moving charge is repelled upward by the magnetic field of the solenoid.
  - Steel plunger is lifted slightly to open the orifice and allow gas to flow through the valve.

#### Results and Conclusion

- **Using 1000 V over the capacitors generates a peak current of 12 kA**
  - Equivalent to a magnetic field of 1.08 T and a force of 995 N.
- **Produces 70 μm rise time over 1 mm gap based on output of fiber optic sensor**
  - Much faster than a greater percentage of valves available today.
- **Multiple aspects to further investigate**:
  - Composition of moving disks (steel and aluminum laminates).
  - Reducing inductance of solenoids within the valve.
  - Using different locations for gas inlet to aid rise times.

### References

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**Abstract**

This research investigates various methods of fast moving valve operation, namely piezoelectric and electromagnetic methods. Due to certain insufficiencies in existing methods, we designed our own electromagnetic “moving disk” valve capable of both static and pulsing operation, and after testing a prototype of this design, we found it to be capable of 70 μm rise times with even faster times possible with further optimization. This technology is mainly applicable in fusion research, but further applications may present themselves in the future.

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